REMARKS

Claims 1-4 are pending and have been examined in the present application.

Claim 1 stands rejected under 35 U.S.C. §102(b) as being anticipated by JP10-242720. Claim 2 stands rejected under 35 U.S.C. §103(a) as being unpatentable over JP10-242720 in view of the article by Rose. Claims 3-4 stand rejected under 35 U.S.C. §103(a) as being unpatentable over JP10-242720 in view of the article by Rose, and further in view of the article by Van Zant. Applicants respectfully traverse these rejections.

Among the limitations of independent claim 1 which are neither disclosed nor suggested in the prior art of record is a method of adjusting characteristics of an electronic part which includes "performing an electromagnetic field simulation to determine a value of said characteristic which is to be obtained when the value of at least one structural parameter of said electronic part is varied from a design value."

Similarly, among the limitations of independent claim 2 which are neither disclosed nor suggested in the prior art of record is a method of adjusting characteristics of an electronic part which includes "performing an electromagnetic field simulation to determine a value of said characteristic which is to be obtained when the value of at least one of a plurality of structural parameters of said electronic part is varied from a design value."

With the use of an electromagnetic field simulation, it is possible to quickly determine the amount of adjustment needed to achieve the desired characteristics of the electronic part. This determination also diminishes the risk of over-adjusting the structural portions of the electronic part that arises from prior art adjusting methods which use trial-and-error, or equivalent circuit techniques. See paragraphs [0004]-[0011] of the specification.

JP10-242720 teaches that the desired value of the resonant frequency is set, and then the depth/diameter of a hole provided in a dielectric block is adjusted to meet the desired resonant frequency. JP10-242720 does not teach or suggest performing an electromagnetic field simulation to determine a value of the characteristic which is to be obtained when the value of at least one structural parameter of the electronic part is varied from a design value, as required by independent claims 1 and 2. For the Examiner's convenience, an electronic English language translation of JP10-242720 from the Japanese Patent Office database is attached.

The article by Rose and the article by Van Zant do not remedy any of the deficiencies of JP10-242720. Neither of these references teach or suggest performing an electromagnetic field simulation to determine a value of the characteristic which is to be obtained when the value of at least one structural parameter of the electronic part is varied from a design value, as required by independent claims 1 and 2. Therefore, even if one were to combine the teachings of JP10-242720, Rose and Van Zant, one would not arrive at the present invention as defined in independent claims 1 and 2.

Accordingly, it is respectfully submitted that independent claims 1 and 2 patentably distinguish over the prior art of record.

Claims 3 and 4 depend either directly or indirectly from independent claim 2 and include all of the limitations found therein. Each of these dependent claims include additional limitations which, in combination with the limitations of the claims from which they depend, are neither disclosed nor suggested in the art of record. Accordingly, claims 3 and 4 are likewise patentable.

In view of the foregoing, favorable consideration and allowance of the present application with claims 1-4 is respectfully and earnestly solicited.

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Respectfully submitted,

By Richard LaCava

Richard LaCava
Registration No.: 41,135
DICKSTEIN SHAPIRO MORIN & OSHINSKY LLP
1177 Avenue of the Americas
41st Floor
New York, New York 10036-2714
(212) 835-1400
Attorney for Applicant

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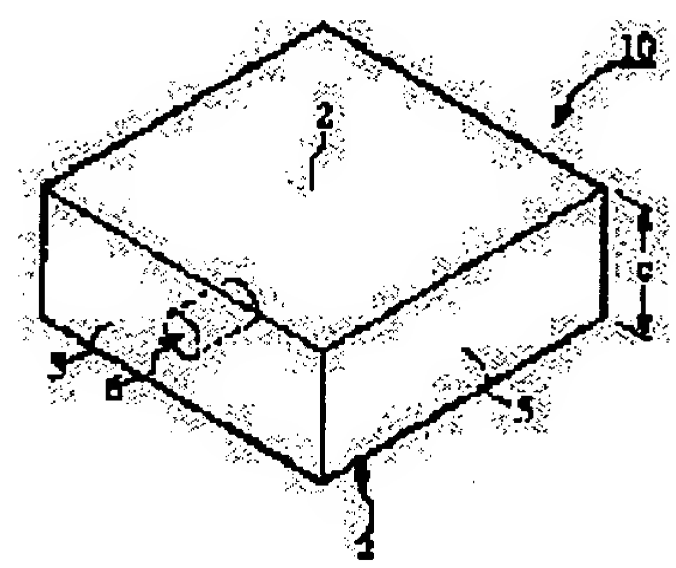
(71)Applicant : MURATA MFG CO LTD
(72)Inventor : KUBOTA KAZUHIKO
ISE TOMOYUKI

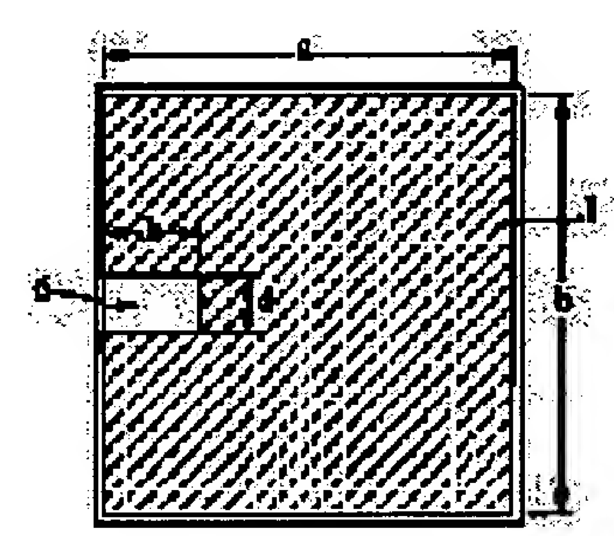
(54) DIELECTRIC RESONATOR AND DIELECTRIC FILTER

(57)Abstract:
PROBLEM TO BE SOLVED: To prevent the leakage of an electromagnetic field and the deterioration of no-load resonance sharpness Qo by forming an electrode of a plane part as a thin film multilayer electrode where both thin film electrode and dielectric layers are alternately laminated and the peripheral part of every thin film electrode layer is short-circuited and then forming a hole on a face almost vertical to the plane part of a dielectric plate or post.
SOLUTION: A thin film multilayer electrode 2 is formed at a plane part by laminating alternately both thin film electrode and dielectric layers and short-circuiting the peripheral part of every thin film electrode layer. When the resonance frequency of a dielectric resonator of such a constitution is controlled, a hole 6 is formed on a face vertical to the upper and lower plane parts of a dielectric plate 1. The change of the resonance frequency is increased when the depth of the hole 6 is controlled at a position near the center of the plate 1, and the resonance frequency is finely controlled when the depth of the hole 6 is controlled at a position excluding the center of the plate 1. Thus, it's possible to decide the size of the hole 6 in order to secure the prescribed resonance frequency even in a design step.

(A)



(B)



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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the dielectric resonator and dielectric filter which are mainly used with a microwave band or a millimeter wave band.
[0002]
[Description of the Prior Art] Before, the dielectric resonator of the TM mode in which the electrode was formed on the front face of a dielectric plate or a dielectric column is used as a dielectric resonator of the microwave band which treats high power comparatively, for example. Since small and high unloaded Q (Qo) is obtained, the dielectric resonator of this TM mode is used as a filter of the communication equipment in the base station of the cellular system for mobile communications etc.
[0003] When it constitutes a filter etc. using the dielectric resonator of the TM mode in which the electrode was formed on the front face of such a dielectric plate or a dielectric column, even if it only designs the specific inductive capacity and the dimension of a dielectric plate or a dielectric column, the resonance frequency as a design is difficult to get by dispersion in an ingredient constant, or the effect of shaping precision like the case where the dielectric resonator of other formats is used. Therefore, fine tuning of resonance frequency is usually needed. Moreover, though dispersion in the ingredient constant of a dielectric plate or a dielectric column or a dimension is fully suppressed, if it is going to obtain the dielectric resonator with which resonance frequency differed using the same metal mold, surface electrode patterns will be made to differ according to the property.
[0004] Then, as it considers as the approach of adjusting or setting up the resonance frequency of the dielectric resonator of such the TM mode, for example, is shown in drawing 20 , how to delete partially the electrode of the flat-surface section perpendicular to an electric-field component can be considered. namely, although it be the perspective view in which (A) show the condition before electrode section deletion, and it act in drawing 2020 as a dielectric resonator of the TM mode which have an electric field component in the direction perpendicular to the flat surface section of the upper and lower sides in drawing as an arrow head show all over drawing by forming an electrode in the external surface (sixth page) of a dielectric plate If the part which is concentrating the electric field of the electrode of the flat-surface section is deleted and the electrode agenesis section 7 is formed as shown in (B), a perturbation can be given to electric field and resonance frequency can be changed.
[0005]
[Problem(s) to be Solved by the Invention] if the electrode agenesis section is prepared in a field perpendicular to an electric-field component, since [however,] a part with the high current density of the actual current which it is easy to produce leak of electromagnetic field since electric-field energy is concentrating on the part, and flows an electrode will be deleted in the dielectric resonator of such the TM mode -- the current density in the neighborhood of it -- going up -- the whole conductor -- loss will increase and Qo will deteriorate.
[0006] Moreover, in order for an applicant for this patent to avoid increase of the current density by the skin effect in the boundary part of a dielectric part and an electrode layer and to raise Qo, Although it has applied for what used the electrode of a field perpendicular to an electric-field component as the thin film multilayer electrode which comes to carry out the laminating of a thin film electrode layer and the thin film dielectric layer by turns by Japanese Patent Application No. No. 331316 [08 to] In the dielectric resonator which prepared such a thin film multilayer electrode, if partial deletion of an electrode is performed as shown in drawing 20 , there is a possibility that thin film electrode

layers may short-circuit between layers, and trouble will be caused to the low loss actuation by reduction of current density.
[0007] The purpose of this invention is to solve the problem of electromagnetic-field leak mentioned above, and offer the dielectric filter using a dielectric resonator and it with little degradation of Qo.
[0008]
[Means for Solving the Problem] this invention -- respectively -- a polygon -- or circular -- mutual -- abbreviation -- with the two parallel flat-surface sections In the dielectric resonator which resonates in one or the two modes or more which form an electrode in the front face of the dielectric plate which has a perpendicular field, or a dielectric column, and have an electric-field component in the direction perpendicular to said flat-surface section these two flat-surface sections -- abbreviation -- In order to set up resonance frequency, avoiding the problem of the layer short at the time of suppressing electromagnetic-field leak, and suppressing increase of current density, and forming a thin film multilayer electrode the thin film multilayer electrode made to come to connect the periphery of each thin film electrode layer too hastily a passage according to claim 1 while carrying out the laminating of a thin film electrode layer and the thin film dielectric layer for the electrode of said flat-surface section by turns -- carrying out -- said flat-surface section of said dielectric plate or a dielectric column -- abbreviation -- a hole is formed in a perpendicular field. Since a dielectric plate or a dielectric column will be partially transposed to the matter with low specific inductive capacity (air) by this hole, the effectual electrostatic capacity of the resonator in predetermined resonance mode decreases, and resonance frequency changes with it in the rise direction. Thereby, the resonance frequency of predetermined resonance mode is defined. Or the resonance frequency of coupled modes changes in the rise direction, and the degree of coupling between two predetermined resonance modes is defined.
[0009] moreover, the dielectric resonator of this invention -- a passage according to claim 2 -- said flat-surface section of said dielectric plate or a dielectric column -- abbreviation -- the partial electrode agenesis section is prepared in a perpendicular field, and the resonance frequency of predetermined resonance mode or the degree of coupling between two predetermined resonance modes is defined. Thus, by preparing the electrode agenesis section, the area of a current path becomes small, the effectual inductance of a resonator increases, and resonance frequency changes in the fall direction. Thereby, the resonance frequency of predetermined resonance mode is defined. Or the resonance frequency of coupled modes changes in the fall direction, and the degree of coupling between two predetermined resonance modes is defined.
[0010] According to the dielectric resonator given in claims 1 and 2, since opening of an electrode will be formed in a field parallel to an electric-field component, electromagnetic-field leak becomes small. Moreover, since a part without an electrode will be prepared in the field where current density is small from the first, degradation of Qo decreases. Moreover, since the electrode of the two parallel flat-surface sections is a thin film multilayer electrode, increase of the current density by the skin effect in the boundary part of a dielectric part and an electrode layer is avoided, Qo increases, but since it is unrelated to the thin film multilayer electrode of the flat-surface section, the above-mentioned hole or the electrode agenesis section does not affect an improvement operation of the above Qo by the above-mentioned hole or the electrode agenesis section using a thin film multilayer electrode.
[0011] Moreover, this invention makes each flat-surface section counter, and carries out the laminating of two or more dielectric resonators according to claim 1 or 2. In order to define a filter shape, avoiding the problem of the layer short at the time of being the dielectric filter which combined between dielectric resonators, suppressing electromagnetic-field leak, and suppressing increase of current density, and forming a thin film multilayer electrode a passage according to claim 3 -- the flat-surface section of said dielectric resonator of said dielectric plate or a dielectric column -- abbreviation -- whether a hole is formed in a perpendicular field and a filter shape is defined or a passage according to claim 4 -- the flat-surface section of said dielectric resonator of said dielectric plate or a dielectric column -- abbreviation -- the partial electrode agenesis section is prepared in a perpendicular field, and a filter shape is set up. Thus, by establishing a hole in a field parallel to the electric-field component of a dielectric resonator, or preparing the electrode agenesis section, the prevention of electromagnetic-field leak and the fall of Qo by the dielectric resonator can be prevented, and the low dielectric filter of an insertion loss is obtained that there is little electromagnetic-field leak.
[0012]
[Embodiment of the Invention] The configuration of the dielectric resonator concerning the 1st operation gestalt of this invention is explained with reference to drawing 1 - drawing 5 .

[0013] Drawing in which (A) of drawing 1 shows an appearance perspective view, and (B) shows electromagnetic-field distribution, and (C) are drawings showing the current distribution which flows an electrode section. The thin film multilayer electrode formed in the vertical side in drawing of the dielectric plate with which 2 makes a hexahedron configuration in (A), and 5 are the monolayer electrodes formed in the fourth page which remains.
[0014] In (B), the arrow head of the continuous line in a dielectric resonator expresses the direction of electric field and reinforcement for the principal part, and the arrow head of a broken line expresses field distribution. Thus, if electric field will be distributed in the thickness direction of a dielectric resonator 10, a field will be distributed in the direction of a field perpendicular to it, a x axis and the y-axis are taken in the direction of a flat surface of a field and the z-axis is taken in the direction respectively perpendicular to this, this dielectric resonator can be expressed as the TM110 mode. Thus, since electromagnetic-field distribution arises, as shown in (C) of this drawing, a current will flow in the direction in which it gathers to a center from the direction which spreads from a center to a four way type in the thin film multilayer electrode 2 on top, or a four way type, and a current will flow in the vertical direction in drawing to the monolayer electrode 5.
[0015] Drawing 2 is the sectional view and its partial enlarged drawing of the dielectric resonator shown in drawing 1 . In this drawing, a thin film electrode layer, and 4a, 4b and 4c are thin film dielectric layers, respectively, and 3a, 3b, 3c, and 3d constitute the thin film multilayer electrode 2 by both mutual laminating. It forms by repeating processing in which this thin film multilayer electrode carries out sputtering of the Cu, forms a thin film electrode layer, carries out sputtering of the ingredient of a low dielectric constant from the dielectric plate 1, and forms a thin film dielectric layer, the number of predetermined times. Moreover, the monolayer electrode of a side face is formed by plating of Cu. By preparing after formation of a thin film multilayer electrode, the electrode of this side face short-circuits the periphery of a thin film multilayer electrode.
[0016] Drawing 3 is drawing showing the situation of a current which flows in each thin film electrode layer shown in drawing 2 . The sense (phase) of the current which flows in the thin film electrode layer of a vertical side will gather by each thin film dielectric layers' 4a, 4b, and 4c constituting a respectively very thin dielectric resonator with the thin film electrode layer which exists in those upper and lower sides, as shown in (B) of this drawing, and making each resonance frequency almost equal to the resonance frequency of a dielectric resonator with the dielectric plate 1. As this shows (A), the current ia of a dielectric resonator flows thin film electrode layer 3a, and the current ib of the resonator by thin film dielectric layer 4a flows the thin film electrode layers 3a and 3b. Similarly, the current ic of the dielectric resonator by thin film dielectric layer 4b flows the thin film electrode layers 3b and 3c, and the current id of the dielectric resonator by dielectric layer 4c flows the thin film electrode layers 3c and 3d. Therefore, the synthetic current to which the synthetic current to which the synthetic current which flows to thin film electrode layer 3a flows to ia-ib and thin film electrode layer 3b flows to ib-ic and thin film electrode layer 3c serves as ic-id. The arrow head of the void in drawing expresses the sense and magnitude of these synthetic currents typically. Thus, the current concentration in the surface part of the dielectric plate 1 will be eased, and a current will be distributed by even the surface.
[0017] For example, using the dielectric ceramics of about 40 as the above-mentioned dielectric plate, as each thin film electrode layer, the specific inductive capacity can make resonance frequency of the dielectric resonator by each thin film electrode layer almost equal to the resonance frequency of a dielectric resonator with the dielectric plate 1, when specific inductive capacity uses a dielectric lower than 40. Moreover, without each thin film electrode layer covering completely the electromagnetic field of a dielectric resonator with a dielectric plate or a dielectric column, the thickness of each thin film electrode layer is comparable as the skin depth in resonance frequency, or let it be thickness thinner than it so that the dielectric resonator by each thin film electrode layer and the thin film dielectric layer may combine with a dielectric plate or a dielectric resonator with a dielectric column.
[0018] Now, when adjusting the resonance frequency of the dielectric resonator of such structure, a hole 6 is formed in a field perpendicular to the flat-surface section of the upper and lower sides of a dielectric plate as shown in drawing 4 . (A) of this drawing is a perspective view, and (B) is a horizontal sectional view. In this example, since the hole 6 was formed by diamond bur (rotation grinding stone) after forming an electrode in each field of the dielectric plate 1, an electrode does not exist in the inside of a hole 6. The interior of a hole 6 is air, and from the dielectric plate 1, since it is a low dielectric constant, the effectual electrostatic capacity of a resonator decreases [before forming a hole 6]. here -- the effectual electrostatic capacity of a resonator -- Co and an effectual inductance -- Lo, then resonance frequency fo=1/-- {(since it is expressed as 2piroot(LoCo)}, the last twist resonance frequency which forms a hole 6 rises by

fŏrming a hole 6.)
[0019] the dielectric resonator which showed drawing 5 to drawing 4 -- setting -- the specific inductive capacity epsilonr37 of the dielectric plate 1 -- carrying out -- a=b=14[mm] c= 4 [mm] d= 2 [mm] ****** -- it is the result of calculating the variation of the resonance frequency when changing h, and the resonance frequency to the variation of h by FEM simulation. Here, these numerical results are shown by making variation of fo [as opposed to / as opposed to / for resonance frequency / fo / the variation of dfo and h for the variation] into dfo/dh.
[0020]
h[mm] fo[MHz] dfo[MHz] dfo/dh [MHz/mm] 0.0 2489. 3 0.5 2489. 4 0.1 0.2 1.0 2490. 1 0.7 1.4 1.5 2491. 8 1.7 3.4 2.0 2495. 0 3.2 6.4 2.5 2500. 0 5.0 10.0 3.0 2507. 1 7.1 14.2 3.5 2516.49.318.6 4.0 2527.911.5 23.0 4.5 2541.914.0 28.0 5.0 2558.2 16.3 32.6 5.5 2576.9 18.7 37.4 6.0 2597.620.7 41.4 6.5 2620.322.7 45.4 7.0 2644. 7 24.4 48.8 7.52670.3 25.6 51.2 8.0 2696. 5 26.252.4 8.52722.7 26.2 52.4 9.0 2747. 9 25.2 50.4 9.5 2771.4 23.5 47.0 10.0 2792. 4 21.0 42.0 10.5 2810.0 17.6 35.2 11.0 2824. 2 14.2 28.4 11.5 2834.8 10.6 21.2 12.02841.9 7.1 14.2 12.5 2846.4 4.5 9.0 13.0 2848. 6 2.2 4.4 13.5 2849.4 0.8 1.6 In this way The resonance frequency in the time of deleting only the electrode of the part which should form h= 0 [6], i.e., a hole, is 2489.3 [MHz], and it is h= 13.5 [mm]. The resonance frequency when carrying out was set to 2849.4 [MHz]. Moreover, h=8.0-8.5 [mm] The variation of resonance frequency to the variation which it is at the time h serves as max, and it is 52.4 [MHz/mm]. It became. Thus, by [of a dielectric plate] adjusting the depth of a hole 6 near a center mostly, resonance frequency can be changed a lot and resonance frequency can be finely tuned by avoiding the central part of a dielectric plate conversely and adjusting the depth for a hole 6. In addition, although the hole 6 was formed in the explanation mentioned above after forming an electrode in the external surface of a dielectric plate, a hole 6 is really fabricated and you may make it really [the] set up resonance frequency with the depth of the hole 6 at the time of shaping at the time of shaping of a dielectric plate. That is, resonance frequency is not tuned finely but you may make it design the dimension of a hole 6 so that predetermined resonance frequency may be obtained from a design stage.
[0021] Next, the configuration of the dielectric resonator concerning the 2nd operation gestalt of this invention is explained with reference to drawing 6 and drawing 7 .
[0022] With this 2nd operation gestalt, although the 1st operation gestalt showed the example which forms a hole in a dielectric plate and sets resonance frequency as it, as shown in drawing 6 , the electrode agenesis section 7 is formed in the side face in drawing of a dielectric plate, and resonance frequency is set up. (B) of drawing 6 shows typically the current distribution which flows to the electrode of the side face in which this electrode agenesis section 7 was formed. Thus, since the area in which a current flows becomes narrow and the effectual inductance of a resonator increases, resonance frequency falls compared with the case where the electrode agenesis section 7 is not formed.
[0023] the dimension of each part which showed drawing 7 to drawing 6 -- setting -- the specific inductive capacity epsilonr37 of the dielectric plate 1 -- carrying out -- a=b=14[mm] c= 4 [mm] the width of face u2 of the height direction of the electrode agenesis section 7 -- 4 [mm] ** -- it is the result of asking for the resonance frequency when carrying out and changing the width of face u1 of the longitudinal direction of the electrode agenesis section 7 by FEM simulation. Here, these numerical results are shown by making variation of fo [as opposed to / as opposed to / for resonance frequency / fo / dfo and the variation of u1 for the variation] into dfo/du1.
[0024]
u1[mm] fo[MHz] dfo[MHz] dfo/du1 [MHz/mm] 0.0 2489. 3 0.5 2488. 8 1.0 2486. 6 - 2.2 - 4.4 1.5 2480. 2 - 6.4 - 12.8 2.0 2473. 3 - 6.9 - 13.8 2.5 2460. 7 - 12.6 - 25.2 3.0 2446.6 -14.1 -28.2 the resonance frequency before forming u1=0 [7], i.e., the electrode agenesis section, in this way -- 2489.3 [MHz] -- it is -- u -- 1= 3.0 [mm] ** -- the resonance frequency when carrying out was set to 2446.6 [MHz]. Moreover, the variation of resonance frequency to the variation of u1 becomes large, so that u1 is enlarged. Thus, resonance frequency can be changed a lot and resonance frequency can be finely tuned by expanding the width of face of the electrode agenesis section 7 in the minute range conversely, so that the width of face of the electrode agenesis section 7 can adjust resonance frequency in the fall direction and width of face of the electrode agenesis section 7 is enlarged.
[0025] In addition, although it can prepare when the electrode agenesis section 7 shown in drawing 6 also deletes the electrode beforehand formed like the case of the 1st operation gestalt using diamond bur etc., it will be very difficult to delete only an electrode actually, and some dielectric plates will be cut with an electrode in fact. Therefore, what is necessary is just to enlarge the amount of cutting of a dielectric plate (depth of a hole), in order to extend the range of the electrode agenesis section and to raise resonance frequency, while making the cutting depth as shallow as possible,

in order to reduce resonance frequency.
[0026] Next, the configuration of the dielectric resonator concerning the 3rd operation gestalt is explained with reference to drawing 8 - drawing 10 .
[0027] Drawing 8 is the perspective view and horizontal sectional view of a dielectric resonator. The thin film multilayer electrode formed in the vertical side in drawing of the dielectric plate with which 2 makes a hexahedron configuration in (A), and 5 are the monolayer electrodes formed in the fourth page which remains. This dielectric resonator is TM duplex mode dielectric resonator using the TM210 mode and the TM120 mode, as mentioned later, in order to combine the TM210 mode and the TM120 mode using the mode and the two modes in the mode (TM210-TM120) so that it may mention later (TM210+TM120), is made into the configuration which removed one corner of a dielectric plate, and establishes a hole 6 in a part for that corner.
[0028] Drawing 9 is drawing showing the situation of electromagnetic-field distribution of the coupled modes between two the above-mentioned mode and its two modes. (A) and (B) are drawings about the TM120 mode and the TM210 mode, and the arrow head of a broken line shows field distribution. These two modes have a degenerate mode relation. (C) of this drawing and (D) are drawings about the mode and the mode (TM210-TM120) which are used as coupled modes (TM210+TM120), respectively, and the arrow head of a broken line shows field distribution. By considering as the configuration which removed the corner of a dielectric plate as shown in this drawing, the resonance frequency in the mode becomes high in this example (TM210-TM120), since the resonance frequency in the mode (TM210+TM120) seldom changes, degeneration in the TM120 mode and the TM210 mode is dispelled and association produces it among both the modes in the TM120 mode and the TM210 mode.
[0029] Drawing 10 sets specific-inductive-capacity epsilonr of the dielectric plate 1 to 37 in (B) of drawing 8 , and is a=b=22 and c= 4 [mm]. It is the bore d of a hole 6 [mm] 2 It is the result of asking for the resonance frequency when carrying out and changing depth h of a hole 6 by FEM simulation. Here, these numerical results are shown by setting variation of f1 [as opposed to / in the resonance frequency in f1 and the mode (TM210+TM120) / resonance frequency / of the mode (TM210-TM120) / the variation of df1 and h for the variation of f2 and f1] to df1/dh.
[0030]
h[mm] f1[MHz] f2[MHz] df1 [MHz] df1/dh [MHz/mm]
0.0 2520.9 2504.8 0.5 2520.9 2504.8 0.0 0.0 1.0 2521.2 2504.8 0.3 0.6 1.5 2521.9 2504.8 1.0 1.4 2.0 2523.2 2504.8 2.3 2.6 2.5 [2525.2] 2504.84.3 4.0 3.0 2528.2 2504. 87.3 6.0 3.5 2532.0 2504. 8 11.1 7.6 4.0 2536.92504.8 16.0 9.8 4.52542.9 2504. 822.0 12.0 5.0 2549.7 2504. 9 28.8 13.6 5.5 2557.52505.0 36.6 15.6 6.0 2566. 0 2505. 0 45.1 17.0 6.5 2575. 1 2505. 0 54.2 18.2 7.0 2584.5 2505.1 63.618.8 The resonance frequency of one resonance mode can be adjusted in the rise direction by making the depth of the hole 6 of a corner deep in this way. Moreover, the variation of resonance frequency to the variation of h becomes large, so that depth h of a hole 6 is made deep until it reaches in the center of a dielectric plate. In addition, the difference with the resonance frequency f1 and f2 in the phase which deleted the electrode of the part which should form h= 0 [6], i.e., a hole, is because it considered as the configuration which removed one corner of a dielectric plate.
[0031] The degree of coupling k in the TM120 mode and the TM210 mode is k=2(f1-f2)/(f1+f2) here.
Or k=(f1-f2)/root (f1, f2)
It comes out, and since it is expressed, degree of coupling can be increased by giving a difference to f1 and f2, so that the TM120 mode and the TM210 mode can be combined, a hole 6 is made deep and the difference of f1 and f2 is enlarged.
[0032] Drawing 11 and drawing 12 are drawings showing the configuration of the dielectric resonator concerning the 4th operation gestalt, and a different point from the 3rd operation gestalt adjusts the resonance frequency of one resonance mode of the coupled modes by forming the electrode agenesis section 7 in the corner of a dielectric plate, as resonance frequency is not adjusted but it is shown in drawing 11 by the hole. drawing 12 -- drawing 11 -- setting -- the specific inductive capacity epsilonr37 of the dielectric plate 1 -- carrying out -- a=b=22[mm] c= 4 [mm] the width of face u2 of the height direction of the electrode agenesis section 7 -- 4 [mm] ** -- it is the result of asking for the resonance frequency when carrying out and changing the width of face u1 of the longitudinal direction of the electrode agenesis section 7 by FEM simulation. Here, these numerical results are shown, using variation of f1 [as opposed to / in the resonance frequency in f1 and the mode (TM210+TM120) / resonance frequency / of the mode (TM210-TM120) / the variation of df1 and u1 for the variation of f2 and f1] as df1/du1.
[0033]

h[mm] f1[MHz] f2[MHz] df1 [MHz] df1/du1 [MHz/mm]
0.0 2520.9 2504.8 1.0 2519.9 2504.8 2.0 2514.8 2504.8 2.5 2510.0 2504.8 -4.8 -9.6 3.0 2504.6 2504.8 -5.4 -10.8 3.5 2498.1 2504.8 -6.5 -13.0 4.0 2490.8 2504.8-7.3 -14.6 The width of face of the electrode agenesis section 7 of a corner can adjust the resonance frequency of one coupled modes in the fall direction in this way. When this gives a difference to f1 and f2, the TM120 mode and the TM210 mode can be combined, and degree of coupling can be increased, so that width of face of the electrode agenesis section 7 is made large and the difference of f1 and f2 is enlarged.
[0034] Next, the configuration of the dielectric filter concerning the 5th operation gestalt is explained with reference to drawing 13 - drawing 15 .
[0035] Drawing 13 is the perspective view and fragmentary sectional view of a dielectric filter which were constituted combining four dielectric resonators. In (A), 11, 12, 13, and 14 are the same dielectric resonators as fundamentally as what was shown in drawing 1 , respectively, and form the aperture which becomes an opposed face with dielectric resonators 11 and 12 from the electrode agenesis section shown by W1. The aperture which becomes an opposed face with dielectric resonators 12 and 13 from the electrode agenesis section shown by W2 is formed. Furthermore, the aperture which consists of the electrode agenesis section shown by W3 is formed in an opposed face with dielectric resonators 13 and 14. Moreover, coaxial connectors 15 and 16 are attached in the end face of dielectric resonators 11 and 14, respectively. A thin film multilayer electrode is formed in the top face in drawing of [12 and 13] these dielectric resonators, and the inferior surface of tongue in drawing of dielectric resonators 11 and 14, respectively, and the usual monolayer electrode is formed in other fields, respectively. When adjusting the property of this dielectric filter, it crawls on the side face of dielectric resonators 11, 12, 13, and 14 again one either which is shown by 61, 62, 63, and 64, the hole of shoes is formed in it, and the depth of that hole adjusts on it.
[0036] (B) of drawing 13 is the sectional view of the installation part of the coaxial connector 15 to a dielectric resonator 11, forms a coupling loop 17 with the central conductor of a coaxial connector 15, and is inserting it in a part for the hole which prepared this in the dielectric plate of a dielectric resonator 11. A coupling loop is similarly formed with the central conductor about a coaxial connector 16, and it is inserting in a part for the hole which prepared this in the dielectric plate of a dielectric resonator 14.
[0037] Drawing 14 is the sectional view showing the joint structure between the dielectric resonator 11 in drawing 13 , and 12. In this drawing, (A) shows electric-field distribution in even mode, and (B) shows electric-field distribution in od mode, respectively. Thus, if there is no electrode of aperture W1 part, since a capacity component will decrease to od mode, it is the resonance frequency fodd in od mode. It becomes higher than the resonance frequency feven in even mode, and between dielectric resonators 11-12 carries out electric-field association.
[0038] Drawing 15 is drawing showing the integrated state between the dielectric resonator 12 shown in drawing 13 , and 13. (A) shows field distribution in od mode and (B) shows field distribution in even mode, respectively. Thus, if there is no electrode of aperture W2 part, an inductance component will increase, the resonance frequency in even mode will fall, it will become the relation of fodd >feven, and between a dielectric resonator 12 and 13 will carry out field association. Electric-field association is carried out by existence of aperture W3 like between 11 and 12 between the dielectric resonator 13 shown in drawing 13 R> 3, and 14. It joins together in the path of the coaxial connector 15 -> dielectric resonator 11 ->12 ->13 ->14 -> coaxial connector 16, and the dielectric filter shown in drawing 13 after all acts as a filter which has the band-pass filter property which consists of four steps of resonators. Although this filter shape becomes settled with the resonance frequency of each dielectric resonators 11-14, and the degree of coupling between resonators, in this example of a configuration, it sets degree of coupling constant and defines a filter shape by setting up the resonance frequency of each resonator with the depth of the holes 61-64 shown in drawing 13 .
[0039] Drawing 16 is the perspective view of the dielectric filter concerning the 6th operation gestalt. A different point from the dielectric filter shown in drawing 13 is a point of replacing with setting up the resonance frequency of each resonator, preparing the electrode agenesis section, and having adjusted resonance frequency by formation of a hole. That is, in drawing 16 , the magnitude of the electrode agenesis sections 71, 72, 73, and 74 adjusts each resonance frequency of dielectric resonators 11, 12, 13, and 14, and a filter shape is defined by this.
[0040] Next, the configuration of the dielectric filter concerning the 7th operation gestalt is explained with reference to drawing 17 and drawing 18 .
[0041] While 11 and 12 are the dielectric resonators in TM duplex mode, respectively, forming a thin film multilayer electrode in the vertical side in drawing of a dielectric plate and forming a monolayer electrode in a peripheral surface in drawing 17 , the aperture W which consists of the electrode agenesis section is formed in the plane of composition of

two dielectric resonators. Moreover, the coaxial connectors 15 and 16 which have a coupling loop are put in order and formed in the interior in the same field, respectively. When adjusting the property of this dielectric filter, the hole of 61 for a corner of dielectric resonators 11 and 12, either which is shown by 62, or both is formed, and that depth adjusts.
[0042] Drawing 18 is drawing showing the resonance mode and the integrated state of the dielectric resonators 11 and 12 shown in drawing 17 , and the arrow head of a broken line shows field distribution, respectively. As (A) of drawing 18 and (B) show, the two above-mentioned dielectric resonators 11 and 12 resonate in the TM120 mode and the TM210 mode which have a degenerate mode relation, respectively, and carry out field association of the coupling loop of the coaxial connectors 15 and 16 shown in drawing 17 at the TM120 mode of dielectric resonators 11 and 12, respectively. (C) of drawing 18 is a dielectric resonator 11 and drawing showing the integrated state between 12, and in order that there may be no electrode in an aperture W part, TM210 modes will carry out field association. Moreover, by considering as the configuration which removed the corner of a dielectric plate, a difference arises in the resonance frequency in the TM210 mode, the mode which is the coupled modes in the TM120 mode (TM210+TM120), and the mode (TM210-TM120), degeneration is dispelled and association arises between the two modes in the TM210 mode and the TM120 mode. Therefore, it joins together in order of the TM120 mode -> coaxial connector 16 of the TM210 mode -> dielectric resonator 12 of the TM210 mode -> dielectric resonator 12 of the TM120 mode -> dielectric resonator 11 of the coaxial connector 15 -> dielectric resonator 11, and the dielectric filter shown in drawing 17 acts as a band-pass filter which consists of four steps of resonators. In this case, the depth of a hole 61 adjusts the 1st step and the 2nd step of degree of coupling, and the depth of a hole 62 adjusts the 3rd step and the 4th step of degree of coupling, respectively.
[0043] Drawing 19 is the sectional view showing two examples of a configuration of the dielectric resonator concerning the 8th operation gestalt. Although the base used the prismatic form square dielectric plate, the perimeter may consist of dielectric filters by the dielectric resonator and it which were mentioned above as a cavity by using the center section of the dielectric plate as a dielectric column. Namely, while (A) of drawing 19 really fabricates the rectangular pipe-like cavity 22 and the prismatic form dielectric column 21 prepared in the center section and forming the dielectric plates 23 and 24 in opening of a cavity 22 It is the dielectric resonator in the TM110 mode constituted by forming an electrode outside, and resonance frequency can be adjusted also in this structure by establishing a hole in the dielectric plates 23 or 24, or preparing the electrode agenesis section. (B) of drawing 19 really fabricates the closed-end cylinder-like cavity 22 and the cylindrical shape-like dielectric column 21. The disk type-like dielectric plate 23 to the effective area of a cavity 22 moreover, with a wrap It is the dielectric resonator in the TM010 mode constituted by forming an electrode in a peripheral surface, and resonance frequency can be adjusted also in this structure by preparing a hole or the electrode agenesis section in the side face of a cavity 22.
[0044]
[Effect of the Invention] According to invention concerning claims 1 and 2, since opening of an electrode will be formed in a field parallel to an electric-field component, electromagnetic-field leak becomes small. Moreover, since the flat-surface section perpendicular to an electric-field component can form a thin film multilayer electrode all over the, increase of the current density by the skin effect in the boundary part of a dielectric part and an electrode layer is avoided, and Qo increases. And since a hole and the electrode agenesis section are only prepared in the field where current density is small from the first, there is little degradation of Qo by preparing a hole and the electrode agenesis section.
[0045] According to invention concerning claims 3 and 4, by establishing a hole in a field parallel to the electric-field component of a dielectric resonator, or preparing the electrode agenesis section, the prevention of electromagnetic-field leak and the fall of Qo by the dielectric resonator can be prevented, and the low dielectric filter of an insertion loss is obtained that there is little electromagnetic-field leak.

[Translation done.]